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REPORT OF SURVEY CONDUCTED AT

LITTON SYSTEMS INC.
AMECOM DIVISION

COLLEGE PARK, MARYLAND

JUNE 1989

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The purpose of the Best Manufacturing Practices (BMP) survey conducted at this facility was to identify their best practices, review manufacturing problems, and document the results. The intent is to extend the use of progressive management techniques as well as high technology equipment and processes throughout the U.S. industrial base. The actual exchange of detailed data will be between contractors at their discretion. A company point of contact is listed in the report

The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry.

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SECTION 1

EXECUTIVE SUMMARY

1.1 BACKGROUND

The Best Manufacturing Practices (BMP) team conducted a survey at Litton, Amecom Division located in College Park, Maryland. The purpose of the survey was to review and document the best practices and potential industry-wide problems at Litton Amecom. The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry.

1.2 KEY FINDINGS

There were many best practices observed at Litton Amecom that are detailed in this report. Some of the more significant findings included in this report are listed as follows:

Item	Page
Lessons Learned Knowledge/Rule Base Creation of software and a data base consisting of various design rules useful in design and manufacturing	5
Solids Modeling Creation of geometrically accurate 3-D solid models for mechanical components and assemblies to assure fit, produce drawings and documentation, simulate mass properties, and interface directly with CAM operations	8
34 AWG Wire Wrap Use of small wire wrap for high density applications	9
Semi-rigid Cable Bending Automated semi-rigid cable bending operations	9

SECTION 2

INTRODUCTION

2.1 SCOPE

The purpose of the Best Manufacturing Practices (BMP) survey conducted at Litton, Amecom Division was to identify best practices, review manufacturing problems, and document the results. The intent is to extend the use of progressive management techniques as well as high technology equipment and processes throughout industry. The ultimate goal is to strengthen the U.S. industrial base, solve manufacturing problems, improve quality and reliability, and reduce the cost of defense systems.

To accomplish this, a team of Navy engineers supported by a representative of the Army accepted an invitation from Litton Amecom to review the most advanced manufacturing processes and techniques used in their facilities located in College Park, Maryland. Manufacturing problems that had the potential of being industry-wide problems were also reviewed and documented for further investigation in future BMP surveys. The review was conducted on 6-9 June 1989 by the team identified in Appendix B of this report.

The results of BMP surveys are entered into a data base to track best practices and manufacturing problems. The information gathered is available for dissemination through an easily accessible central computer. The actual exchange of detailed data will be between contractors at their discretion.

The results of this survey should not be used to rate Litton Amecom among other defense electronics contractors. A contractor's willingness to participate in the BMP program and the results of a survey have no bearing on one contractor's performance over another's. The documentation in this report and other BMP reports is not intended to be all inclusive of a contractor's best practices or problems. Only selected non-proprietary practices are reviewed and documented by the BMP survey team.

2.2 SURVEY PROCESS

This survey was performed under the general survey guidelines established by the Department of the Navy. The survey concentrated on the functional areas of design, test, production, facilities, logistics, and management. The team evaluated Litton Amecom's policies, practices, and strategies in these areas. Furthermore, individual practices reviewed were categorized as they relate to the critical path templates of the DoD 4245.7-M, "Transition From Development To Production." Litton Amecom identified potential best practices and potential industry-wide problems. These practices and problems and other areas of interest identified were discussed, reviewed, and documented for dissemination throughout the U.S. industrial base.

The format for this survey consisted of formal briefings and discussions on best practices and problems. Time was spent on the factory floor reviewing practices, processes, and equipment. In-depth discussions were conducted to better understand and document the practices and problems identified.

2.3 NAVY CENTERS OF EXCELLENCE

Demonstrated industry-wide problems identified during the Best Manufacturing Practices surveys may be referred to one of the Navy's Manufacturing Technology Centers of Excellence. They are:

Electronics Manufacturing Productivity Facility (EMPF), Ridgecrest, CA

Applied research in the processes and materials involved in the manufacture of circuit card assemblies

Automated Manufacturing Research Facility (AMRF), Gaithersburg, MD

Applied research in the machining processes, within a heterogeneous Computer Integrated Manufacturing environment

Metalworking Technology Incorporated (MTI), Johnstown, PA

Applied research in the metalworking processes

2.4 LITTON AMECOM OVERVIEW

Litton Amecom maintains modern manufacturing and test facilities within its 50 acre physical plant located in College Park, Maryland. Advanced production capability is an integral part of the Division's strategic business operations. The physical plant consists of four major facilities and two outdoor test ranges, totaling over

375,000 ft^2. The Division employs over 1,200 personnel, with approximately 40 percent involved in procurement, manufacturing, test, and quality control.

Litton Amecom develops, produces, and supports sophisticated electronics systems in two technology areas: electronic warfare and telecommunications. Approximately 90 percent of Litton Amecom's annual sales are for the U.S. Government, with primary customers being the Department of Defense, the Federal Aviation Administration, and aerospace prime contractors.

Since 1975, Litton Amecom has produced and integrated over 230 electronic warfare systems, 90 RF Communications systems, and 70 telecommunications systems. Each of these systems contains approximately 24 primary units (e.g., WRAs and LRUs), and all of the systems have been produced in accordance with military process and quality standards.

Major production programs have included AN/ALR-73 passive detection system; the AN/ALQ-125 tactical electronic reconnaissance system; the AN/BLD-1 precision direction-finding system; the LR-4500 microwave collection system; the HF exterior communications suite and damage/fuel control systems for DD-963, DDG-993, and CG-47 ship classes; the HF communications equipment for the Saudi Arabian Air Defense Forces C3 system; and the integrated communications switching system for over 60 airports and flight service stations across the United States

Litton Amecom's modern production facility, constructed in 1984, provides a complete capability for electronics manufacturing and test. The 128,000 ft^2 facility uses an open floor concept that provides for optimum material flow throughout the building, as well as for the integration of assembly and test processes. Specifically, the facility includes the following specialized areas: a 4,480 ft^2 receiving inspection area; an 11,000 ft^2 stock room with automated storage and retrieval systems; a 5,600 ft^2 clean room; an 11,200 ft^2 fabrication shop; a 13,150 ft^2 area for assembly of circuit cards, semi-rigid cable, wire wraps, and harnesses; a 7,100 ft^2 environmental test lab; and 8,500 ft^2 test engineering laboratory; and a 3,300 ft^2 failure analysis and microcircuit evaluation lab.

Automated assembly and test equipment is used throughout the production floor to maximize quality and productivity. Using this automated equipment, Litton Amecom has demonstrated the capability to produce the following types of assemblies and subassemblies on a one-shift basis: printed circuit boards (42,000/year); wire harnesses and flex/standard cable subassemblies (35,000/year); semi-rigid cable subassemblies (17,500/year); antenna subassemblies (580/year); module-level assemblies (8,800/year); and primary units (2,900/year).

2.5 ACKNOWLEDGEMENTS

Special thanks are due to all the people at Litton Amecom whose participation made this survey possible. In particular, the BMP Program acknowledges the special efforts of Mr. Tony Corrado, Vice President of Operations, for enabling this survey to occur.

2.6 LITTON AMECOM POINT OF CONTACT

While the information included in this report is intended to be descriptive of the best processes and techniques observed at Litton Amecom, it is not intended to be all inclusive. It is anticipated that the reader will need more detailed data for true technology transfer.

The point of contact for this BMP survey is:

Vito Donofrio
Director of Operations Planning
(301) 864-5600, Extension: 2020

Litton
Amecom Division
5115 Calvert Road
College Park, MD 20740 - 3898

Mr. Donofrio's cooperation, time, and quality of effort in preparation and hosting of this survey at Litton Amecom and participation in the Best Manufacturing Practices program is greatly appreciated.

SECTION 3

BEST PRACTICES

The practices listed in this section are those identified by the BMP survey team as having the potential of being among the best in the electronics industry.

3.1 DESIGN

DESIGN PROCESS

LESSONS LEARNED KNOWLEDGE/RULE BASE

Litton Amecom is creating a powerful knowledge base consisting of various design rules useful in the transition between design and manufacturing. In effect, the concept focuses on cumulative rather than individual knowledge on product development. Under rule base design, the design team conducts an evolving design while using a rule base that constrains options that could be detrimental, thus forcing intelligent trade-offs. In addition, by adding a knowledge base, the concept leads development teams to optimum conclusions, where a rule base alone only prevents detrimental choices.

The knowledge and rules compiled within the data base come from various sources. One of the main sources consists of material derived from various problem investigation reports. Other sources include military standards, reliability physics journals, and manufacturing constraints.

Many organizations rely on experienced individuals or publications as sources for design rules, which creates the potential for losing or overlooking valuable information over a period of time. The knowledge/rule base concept addresses this problem by providing an optimum repository for storing and compiling rules. It is easily accessible, maintainable, and transportable. In effect, it keeps the knowledge "off the dusty shelves."

The nature of the data storage is more than just a data base. The software is actually an artificial intelligence (AI) architecture with the capability of helping the user achieve several levels of information cross-reference. The use of AI is a natural evolution because of its potential for on-line use with Computer-Aided Design (CAD), Computer-Aided Engineering (CAE), and Computer-Aided Manufacturing (CAM). In fact, AI was found to be helpful for the more complicated rules which require implementing algorithms.

The data base is intended to benefit users with backgrounds in all phases of design and manufacturing including electrical, mechanical, reliability, test, components, and manufacturing engineering. Ultimately, issues to be addressed in the data base will include not only reliability and producibility guidelines, but also performance and economic trade-offs. In general, the knowledge/rule base developed by Litton Amecom promises to be a very powerful tool which will smooth the transition between design and manufacturing.

ADVANCED MANUFACTURING ENGINEERING

Litton Amecom's manufacturing engineering organization is involved in the entire development process to assure producibility of designs. This participation begins with membership on the proposal team where conceptual designs are influenced. The manufacturing representative is responsible for early identification of areas requiring producibility analysis, and contributing to trade studies. Manufacturing engineering is also responsible for the publication of design guidelines. These guidelines communicate manufacturing design criteria to the engineering department. Benefits achieved through the application of guidelines during product design are minimizing design changes, capital investment, manufacturing costs, and tooling costs. The guidelines also increase manufacturing yields and improve quality.

Design review participation by manufacturing engineering assures that manufacturing issues are addressed early in the development process. Constant involvement of manufacturing is assured through this mandatory participation. Early identification of design features requiring the development of new manufacturing processes is also a benefit of involvement in all design reviews. All engineering drawings require sign-off by manufacturing engineering prior to release. This approval cycle ensures the design incorporates producibility concepts before fabrication is initiated. This results in fewer drawing changes, increased manufacturing yields, and lower production costs. This process also leads to a standardization of the drawing format, which is easily understood by manufacturing.

Maintenance of state-of-the-art manufacturing facilities is a by-product of manufacturing engineering's involvement in the development process. The insight gained as to what technologies that engineering is contemplating for next generation systems allows manufacturing to prepare both facilities and procedures. This

improves and speeds the transition from design to production. Improved communications also aids the entire organization in sharing lessons learned.

MICROWAVE SUBSYSTEM DESIGN

Litton Amecom has organized their microwave subsystem design group so that hardware designers have a significant impact on system architecture. The hardware engineers are the designers of the microwave subsystem. Their involvement begins at the proposal phase where they work with the systems engineers on interface requirements and the functional partitioning of the system. This involvement includes performing hardware simulation during design conceptualization to assure the ability of the proposed system to meet the performance specification. They also perform trade studies of Weapons Replaceable Assembly (WRA) specifications versus cost and feasibility of hardware. Simulation is performed with a mix of commercial and Litton Amecom proprietary software. This simulation covers areas such as spurs/frequency plan, noise figures, bandwidth, gain budget, LO levels, dynamic range, and functional partitioning into WRAs. Models of subsystem components can be made to prove feasibility.

The result of these efforts is the translation of performance specifications into realizable Shop Replaceable Assembly (SRA) specifications. The ability of Litton Amecom or a vendor to meet the subsystem specification has been assured. These engineers also work with design assurance engineers to satisfy maintainability, testability, and reliability requirements early in the design cycle. This approach results in reduced risks and a faster development process.

MULTI-DISCIPLINED DESIGN TEAMS

Litton Amecom is very active in the development and implementation of multi-disciplined teams within their organization. In addition to their "Perfect Team" Concept, they have established two other key team types, Product Teams and Technology Teams.

The key concept driving these teams is Litton Amecom's belief that they can minimize cost and schedule by ensuring that testability, manufacturability, maintainability, and quality issues are addressed early in the design phase. They achieve this end by assembling a team of key people representing these disciplines.

The results have been the minimization of capital investment as designs can be tailored to use existing capital equipment, better designs, and fewer design changes. These benefits combine to lower production costs and speed the development and manufacturing processes.

One successful product development team was assembled for the TRUMP project for the development of a control console for shipboard liquid level management. Delivery of the first unit was to be accomplished in nine months, with three units to follow at three month intervals. Litton Amecom assembled a design team composed of industrial, test, mechanical, and systems engineers. A build team was also assembled consisting of industrial, production, material, configuration, and project management experts. The teams set goals for themselves and met regularly to identify and resolve all program issues. The result of their efforts was that the four units were delivered significantly under cost and ahead of schedule.

Another type of team concept active at Litton Amecom is the technology team. This team is assembled to solve, in minimal time, the technical issues concerning new technology. One success story was a team which was assembled to address a surface mount manufacturing problem. They assembled a small team with expertise in manufacturing, reliability, and design disciplines, and gave the team both the responsibility and the authority to go off and solve the problem with minimal management intervention. The team worked closely among themselves and with their materials suppliers. The end result was that they took a design from an Engineering Development Model (EDM) to a completed surface mount assembly in five months.

In the process, they also developed a sheet adhesive for attaching the printed circuit board (PCB) to the frame, an innovative solution which won them the award for best applications paper by the Society of Manufacturing Engineers, as well as drastically improving their manufacturing process.

DESIGN ANALYSIS

AUTOMATED ANTENNA MANAGEMENT SYSTEM

The antenna design section of the engineering department of Litton Amecom has developed a state of the art Automated Antenna Measurement System (AAMS). This system is used in the development phases of antenna designs, and allows Amecom to quickly verify and assure deployed antenna and RF system performance. A key feature of this system is that it allows testing of the antenna in a "real-life" scenario. The unit under development is mounted on a tail-section of the platform on which it will be deployed. This yields data that would not normally be available during system testing.

The system is fully automated, including the system that drives the mock-up tail-section through its various azimuth and elevation angles, the transmit frequency signals, and the receiver matrix switching network. The

data is collected into a central computer, which compiles the millions of data points and can provide printed outputs in various modes, including contour plots. The system can correlate various types of data, such as antenna performance at various frequencies with fixed direction, and frequency performance over varying directions.

Some of the key features which make the AAMS unique are its fully automated measurement system; its speed (over 3.2 million data points in 60 hours), and its accuracy (2 degree RMS phase accuracy and .03 degree range positioning accuracy). The bottom line is that the AAMS allows Litton Amecom to look at a multitude of antenna data, in minimal time, thereby assuring on-schedule delivery of a high performance antenna/RF system.

MICROWAVE INTEGRATED CIRCUIT DEVELOPMENT

Litton Amecom has developed state-of-the-art Microwave Integrated Circuit (MIC) development capabilities. This development capability assists in verifying designs, in providing quick turnaround in engineering to meet first article delivery, and it also provides limited emergency production capability in case vendors experience technical or workloading problems.

Litton Amecom's facility supports all phases of MIC development, from design and analysis, using off-the-shelf as well as custom developed simulation software, to layout, and fabricate MIC devices. They have developed very accurate computer modeling techniques, and assembled a very sophisticated laboratory to implement their designs.

Litton Amecom couples this technical capability with its multi-disciplined team design philosophy to achieve complex designs in minimal time and achieve specification performance within reasonable manufacturing tolerances.

SOFTWARE DESIGN

MANAGING THE SOFTWARE DEVELOPMENT PROCESS

Software Engineering is a relatively small department (approximately 60 people) at Litton Amecom. It uses a hybrid organization in which development is projectized and support functions matrixed. The small size of the department and its organization structure allow a high degree of communication and cross functional participation.

The software people become involved very early in the development cycle. A "Product Champion" is assigned who plans and tracks each function of the system. Short duration milestones (two weeks) are established. These are plotted, updated, and presented to management weekly in a dedicated software "war room." All tasks are tracked against budget. This method allows immediate visibility of variances and schedule slips and permits correction of problems before elevation to higher management. Early involvement of the software engineers in development also includes reviews and acceptance of pertinent requirements information and analysis for completeness, understandability, and implementability.

MISSION EFFECTIVENESS MODEL

Litton Amecom has developed and implemented a unique rule based mission analysis model. The purpose of the model is to assess and define mission benefits derived from operational deployment of sensor capabilities, assess cost and performance of sensor features and improvements, and perform sensor trade-off assessments. Model validity is maintained by obtaining user concurrence in scenario and threat descriptions, emission rules used, sensor models implemented, and the application of analysis techniques. The model provides a realistic scenario environment that can be used to effectively impact system requirements and drive system design issues. The model's integrated environment perspective provides Litton Amecom and the customer with greater confidence in system requirements and a tool to evaluate military effectiveness. It is applicable to any ESM or threat warning system. Litton Amecom uses the model for business development. Users find it very helpful for sensor procurement and modification decisions. The model is fully functional and its modular design allows for continuous updates and improvements.

SYSTEM SOFTWARE DEVELOPMENT PROCESS

Litton Amecom software engineers are involved from the beginning of system development so they can provide input to developing the software requirements for the system. This assures that the software requirement specifications are complete and can be implemented. Advanced tools are used for software development. One of the most powerful of these is an on-line structured method for developing system software design requirements. It is a commercial program produced by Yourdon Inc. called Yourdon Engineering Workbench which runs on a PC. The structured analysis serves as an organizing tool for the designer which links system requirements and design, and assures complete and non-redundant designs. The program facilitates rapid system modeling and design modeling and is self-documenting. It provides an efficient method for transferring design specifications to

software and hardware designers. The structured approach encourages software component modularity for off-the-shelf availability. They have found that many modules can be used in other applications, thereby reducing development, schedule, cost, and performance risk. The modeling and simulation features of the program allow verification of algorithms, subsystems, and system designs. It can also be used to do sensitivity and "what if" analyses and to establish the system design dependent mission effectiveness.

Another tool used by software programmers is an assembly like language invented at Litton Amecom to generate microcode. To further speed the process macros have been developed to generate assembly language. This is much faster because one line of source code can specify multiple microcode functions. It has proven to be comfortable and efficient for programming.

COMPUTER AIDED DESIGN

PRINTED WIRING BOARD DESIGN METHODOLOGY

The Printed Wiring Board (PWB) design methodology is another area where Litton Amecom is applying the multi-disciplined team approach. They are developing a new CAD process using the Mentor simulation system which accommodates schematic generation while utilizing all knowledge gained during the development of concurrent cost and scheduling systems. The process flow is a parallel effort which includes inputs from members of the development team affecting preliminary Mentor data, preliminary engineering information, and the remerged final netlist. The output of the final netlist is routed, cleaned, checked, and subjected to a design rule conformity check before sign-off.

The use of Mentor and periodic process reviews by team members will provide the means to improve cost and schedule commitments. Board design costs are expected to be reduced by 20% to 30%. Although not yet completed, a solid historical data field has been established, based on previous PWB designs for the EA6B program, to allow confidence that the new approach will exhibit these improvements.

There are two significant differences between the new approach and more conventional PWB design processes. The first is the use of the Mentor simulation system in the first step instead of final engineering and drafting information. The second difference is the use of team members to provide periodic inputs to critical processes in parallel with the flow rather than relying on sequential checks at specific stages in the flow. Together with the other stages in the process, Litton Amecom is devising a PWB methodology which promises significant reduction in design cost and time.

Litton Amecom has also developed a computerized quality control process for PWB designs. The process checks final boards for shorted traces, missing or extra pads, spacing, and other board parameters. The process also provides data to check loaded boards for shorted or missing voltages and grounds, as well as improperly inserted capacitors and diodes. This process has significantly maximized CAD system usage while minimizing manual interface.

SOLIDS MODELING

Litton Amecom has adopted a very progressive approach to the application of CAE. Mechanical design is performed using MATRA DATAVISION's Euclid solid modeling software. Geometrically accurate, three-dimensional solid models are created for each mechanical component. These models are used to assure fit at nominal dimensions and simulate mass properties of both the components and assemblies. Drawings are then created through interrogation of the models.

Models, as well as drawings, are placed under configuration control after a print of the drawing has been signed off. The solid model then becomes the basis for the product definition. All subsequent engineering changes are incorporated into both the model and the drawing. Maintenance of the model permits the continuous use of the data throughout the life of the project for simulation, redesign, or the new design of a similar component.

The disciplined application of CAE in the manner described above provides for more mature designs earlier in the development cycle. The ability to solve problems and change designs at any time during the life of the program is enhanced. Another benefit of having up-to-date solids models is the availability of artwork for technical publications. The high quality illustrations which can be extracted from solid models can be used for production instructions, technical manuals, and the addition of isometric views to drawings.

3.2 TEST

FAILURE REPORTING SYSTEM

RELIABILITY ASSURANCE DATA SYSTEM

Litton Amecom has developed a very extensive failure reporting system called the Reliability Assurance Data System (RADS). This system has been integrated into all facets of Amecom's business. Its power comes from its

completeness, accuracy, timeliness, and user friendliness.

Through RADS, component and module reliability and/or performance problems are identified automatically by failure trend and test yield reports. In addition, RADS provides an extremely flexible on-line search/query capability, lending ready access to a variety of detailed failure records dating back to 1980. The system also provides weekly executive summaries that highlight any problem areas, insuring maximum top-level visibility to these areas. The system maintains complete vendor and in-house failure analysis reports on failure items, and maintained current status of all open failure analyses.

The RADS provides a wide range of data to various users. Reliability and design engineers use failure histories, associated failure analysis, and past corrective actions to aid in identifying current failure modes and solutions and to support trend analyses. Procurement personnel use the open failure analysis reports to track the status of vendor items. Management uses RADS reports to monitor the failure activity and yield of the manufacturing product and to aid in budgeting and bidding on new projects. In addition, the RADS is used to support random customer requests for information on failed hardware.

3.3 PRODUCTION

QUALIFY MANUFACTURING PROCESS

34 AWG WIRE WRAP

Litton Amecom has high density applications which pushed the need for small wire wrap usage. Amecom chose to use high density wire wrap due to potential changes and design improvements. Hard connections would not allow for field changes with equipment being driven by changes in threat and design.

Special set-up tools are used in conjunction with the Gardener Denver conventional system. Both hand and machine applications are used for wire wrap of 34 AWG wire. The process uses 34 AWG solid wire with Kapton insulation and is wrapped on 0.015 inch square pin posts. The present military specification, MIL-STD-1130B, does not address wire wrap of 34 AWG wire. Litton Amecom has submitted documentation to expand this specification to include 34 AWG wire.

HEAT SINK LAMINATION

Litton Amecom has successfully developed a method by which Kevlar surface mount circuit cards are laminated onto an aluminum heat sink by utilizing a vacuum bag bonding operation. This module replaces one previously made with copper/invar/copper, which is extremely heavy and has inherent problems with Coefficient of Thermal Expansion (CTE) mismatch. With the aluminum and Kevlar, Litton Amecom found that by providing a silicon fiber adhesive between the materials, the thermal properties were quite acceptable.

The process involves the application of a primer onto the back side of each surface mount assembly and the aluminum heat sink. A 0.015 inch thick silicon fiber adhesive is then placed on the back of each circuit card and attached to the heat sink. The module is placed in a silicon rubber bag and a vacuum is created. Finally, the module is cured at 250 degree F for one hour. This process results in significant weight reduction and an improved CTE match of the materials.

SEMI-RIGID CABLE BENDING

Semi-rigid cables are used in many Litton Amecom designs. As systems become more complex, there was a distinct need to transition from the labor intensive forming operations toward an automated bending process. The NC bend data id derived directly from the three-dimensional model of each cable that is developed using the solid modeling CAD system.

The Teledyne Pines Cable Bender was purchased to perform an automated bending operation with no error accumulation. About 85% of all bending operations are automated. The equipment performs up to 32 compound bends per cable. The EA6B design was accomplished because of the use of the Pines Cable Bender. Major problems probably would have been encountered if those cables were hand bent.

There is an obvious improvement in capability. Overall, a four times improvement was observed. Special cut-off tooling was designed and implemented. The design data base was coupled with computer verified installation. It provides one-to-one drawings including front, top, side, and isometric views which are a distinct advantage for inspection.

PCB TEMPERATURE PROFILING FOR WAVE SOLDERING

Litton Amecom process engineers use the commercially available Multi-channel Occurrent Logger Evaluator (MOLE) temperature profiler to establish the optimum conveyor speed for each board type. The MOLE travels through the wave solder machine with the board to be profiled. Five thermocouples, attached to carefully selected board positions on a production board, provide temperature information to the MOLE for storage and

subsequent playback into a PC. The thermocouples are attached to the component side of the board with a water soluable, Ultra-Violet (UV) cured epoxy to avoid damaging the board. A temperature profile is displayed via software supplied with the MOLE. The optimum conveyor can then be determined and stored for recall by board part number. The target optimum substrate temperature on the component side of the board is 200 degree F (+ 20 degrees - 40 degrees). The PC stores the process set-up information by board part number and is available to the operator.

PIECE PART CONTROL

PIECE PART CONTROL

Litton Amecom has implemented a piece part control system that begins with the piece part requirements being flowed down to the subcontractors via the purchase orders. The Quality Assurance provisions are automatically put on the order by the computer control system. Incoming inspection is performed on material and integrated circuits. Any rejects are analyzed and returned for credit. Poor quality suppliers are identified on a monthly basis and continual problem suppliers are eliminated. Litton Amecom has a real-time automated system that provides the capability of capturing all non-conforming material within the facility. The material shop order system automatically purges all the discrepant material in stock, purges all kits of discrepant material, and freezes all shop orders so that the job can not be worked until the problem is corrected. The way the material stop order system purges discrepant material from throughout the factory prevents discrepant material from being used in a large quantity of assemblies, thus reducing the amount of rework required.

DEFECT CONTROL

CORRECTIVE ACTION BOARD

The Corrective Action Board (CAB) meets monthly. It is co-chaired by the vice presidents of Product Assurance and Operations. Directors of Manufacturing, Test, Operations Control, Industrial Engineering, Quality Control, Reliability, Purchasing, Quality Engineering, Operations Planning, and Production/Material Control make up the CAB members.

A key factor is high lead commitment and involvement on critical problems. Assignments are made and a crisp follow-up procedure gives the process credibility. The board members are held accountable for assignment processing and ultimate resolution.

Problem identification and the resulting resolution compiles information from trends, reliability data, quality, the process, supplier data banks, and other management indicators.

WORKMANSHIP STANDARDS

Litton Amecom is dedicated to maintaining accurate, up-to-date workmanship standards. A manual for microelectronics and another for electrical/mechanical exists. Originally, the manuals were purchased from Martin Marietta. They have been expanded and tailored to meet the needs of Litton Amecom.

When a question arises concerning a standard in the manual, a formal procedure is initiated. The questionable standard and related information is relayed to Quality Engineering (QE). QE then conducts an investigation on the problem and a decision is made as to whether or not a change needs to be made in the manual. If a change is needed, QE issues a Product Assurance Directive (PAD) which explains the revision or change. PADs are also used to define entirely new workmanship standards. All PADs are distributed to quality, manufacturing, DCAS, and Litton Amecom customers to reference until the workmanship standards manual is revised. The revision occurs at least once a year. However, if several PADs have been issued, the manuals are updated more frequently.

COMPUTER AIDED MANUFACTURING

COMPUTER AIDED DESIGN/COMPUTER AIDED MANUFACTURING

The engineering and manufacturing groups at Litton Amecom share their CAD data base via networked Euclid workstations physically located in both areas. This has allowed manufacturing engineers to provide inputs to product designs as they evolve. The procedure has resulted in significant savings by identifying problems before the design is released to the manufacturing floor.

For example, while using the Solid Modeling CAD system it was determined, during the design development of a particular chassis, that there was insufficient space available for the 113 semi-rigid (coax) cables required for the point-to-point wiring. Through use of the CAD system, a smaller diameter cable was substituted and after redrawing all the cable runs, it was determined that all cables would fit into the required space.

Cable geometric information from the Solid Modeling data base is used to feed the semirigid cable bending machine. The ability to design semirigid cables and verify fit before any hardware was built, plus the automatic

programming of the NC cable bending machine, eliminated the need for manual programming and results in time savings and increased accuracy.

Design Engineering, in concert with Manufacturing Engineering, developed application software that extracts geometric and part data from the PWB CAD data base and converted it to a machine language that was readable by the surface mount pick and place machine. This was a great improvement over the tedious program ming method suggested by the equipment manufacturer.

Another example of CAD/CAM capability employed at Litton Amecom involved the use of a company-wide relational data base containing wire list data and the solid modeling CAD data base. The relational data base, ORACLE, contained point-to-point wiring information used as input to the CAD cable harness design program.

The CAD designer uses the cable harness design program to route (autorouting option available) all connectors that make up the cable harness (in "3-D" space) and quickly verify that there are no interferences with surrounding structures. Once the harness is designed on CAD, Manufacturing Engineering can automatically create "harness board" patterns and "lay sequence" graphics and text required to build the harness. Engineering's cable harness documentation is then developed from the CAD design.

MANUFACTURING SCREENING

ENVIRONMENTAL STRESS SCREENING

Litton Amecom has implemented a tailored Environmental Stress Screening program which is called Reliability Enhancement Screening. The program was implemented in 1979 to address the peculiar reliability problems of high frequency components and purchased power supplies. The screening consists of operating and monitored random vibration for ten minutes in the principal axis at 0.4 G2/Hz power spectral density from 80 Hz to 1,000 Hz followed by 48 hours of power-on and monitored thermal cycling. Each cycle consists of two hours at -54 degrees C, two hours at 85 degrees C, and 30 minutes at 105 degrees C. Temperature transitions are at the rate of two degrees C per minute with power-off during cool down and the cold soak. A single critical parameter is monitored for anomolies during the vibration and thermal cycling. The last two thermal cycles must be failure free. The reject rate at the system level has decreased by a factor of greater than four. The failure rate in the field has shown a similar decrease since implementing the screening program.

MANUFACTURING SCREENING

Litton Amecom has implemented integrated circuit testing consisting of continuity, DC, functional, and AC tests at -55 degrees C, 25 degrees C, and 125 degrees C. The testing has been phased in since 1981 when 45% of board test failures were attributed to integrated circuit failures. In 1988, approximately 85% of the integrated circuits were being tested and 20% of board test failures were attributed to integrated circuit failures. The data accumulated by Litton Amecom shows that there is a definite inverse relationship between the number of integrated circuits being tested and the number of board failures attributed to defective integrated circuits. The Litton Amecom testing is more extensive than the industry standard testing at integrated circuit vendors. One to two percent of the integrated circuits fail on receipt. Analysis of the failures show that they are the result of changes made by the manufacturer without notifying the customers of the change, Electrostatic Discharge (ESD) failures due to improper handling at distributors, or being packaged in the tubes backwards. Less than 0.5% of the failures are truly component failures.

3.4 FACILITIES

MODERNIZATION

COMPUTER INTEGRATED WAREHOUSE

Litton Amecom implemented Litton Unit Handling Systems of Hebron, Kentucky computer integrated warehouse system in 1984. The system consists of a robotic automated storage and retrieval system coupled with a DEC PDP-11/34. The system maintains a continuous inventory, has first-in, first-out capability, can maintain co-mingled and logically segregated inventories by contract, and provide various status and inventory reports. A built-in daily check of inventory accuracy is performed on 80 to 100 parts at random for location, part type, contract segregation, and quantity. Any discrepancies are rectified on a daily basis. In 1984, the inventory accuracy was 47%, but after implementation of the automated storage and retrieval system, the accuracy dramatically increased and is continuing to increase. In 1988, the accuracy was 97.5 percent. The system has an up-time of 99.6%. The return on investment to-date has been a factor of two. Before implementation of the system, 24 people were required to perform the storage and retrieval functions, but now all the functions are performed by 12 people and the number may be reduced even further. The system is

88 feet in length, 42 feet in width, and 24 feet in height. There are 3,956 pans with capability of storing 112,500 parts. The system performs an average of 175 transactions per hour. The software for the DEC PDP-11/34 was developed by Amecom.

FACTORY IMPROVEMENTS

PRINTED WIRING BOARD CONFORMAL COATING

Several improvements have produced significant savings in the PWB conformal coating process. Five spray heads provide uniform coating (+/- .0002 inch) of urethane in a single pass per side. A kraft paper conveyor runs at ten inches per minute through the spray chamber, a flash-off area, and a five stage oven.

The elimination of manual masking operations on edge connectors and the heat sink edges reduced the labor time from 30 minutes to five minutes. The new method involves placing the modules in a metal frame with a locking hinge. Litton Amecom hard anodized the metal fixtures to prevent the conformal coating from sticking. They also use paste wax and selected masking. Ten frames will be needed during the engineering production and approximately 30 frames for production. Once the modules finish the process, they are allowed to sit for one hour before handling to complete the curing process. A UV light apparatus is used to inspect the coating.

3.5 LOGISTICS

TRAINING MATERIALS AND EQUIPMENT

LITTON TECHNOLOGY TRANSFER SEMINARS

Litton Amecom actively participates in the Litton Industries Corporate Council of Manufacturing Engineers. This is a formalized program within Litton Industries to transfer technologies among the Litton Divisions. The objective of the program is to meet periodically at a host facility so as to share and exchange information. These seminars help keep Litton Divisions abreast of the latest state-of-the-art technology. Through these technical interfaces, an opportunity is created between the various participating Litton Divisions to exchange information regarding new processes, new materials, and advanced state-of-the-art technology for the mutual benefit of all Divisions. Another objective of these seminars is to identify mutual problems and to establish an interrelated plan and schedule for problem resolution.

Participating divisions host the seminars on a rotating basis such that all equally participate. Seminars are conducted twice a year. Tours of the host facility are included to establish a baseline of equipment and state-of-the-art technology, and to demonstrate new and innovative techniques or equipment that have been implemented.

Attendance is open to senior engineers through directors, usually two or three from each division, and eight or ten divisions participating. The seminars typically cover an extensive two days of presentations covering carefully selected subject matter and speakers. The host activity publishes the minutes/material covered in the seminar which is distributed, as well as maintained, in a library for reference and information by anyone who requests it.

These seminars began in 1978 and the program formalized in 1981 and have proven very successful to Litton Industries in sharing "lessons learned" and avoiding "re-inventing the wheel". A spin-off benefit from the program has been the year-round increased exchange of inter-divisional information and closer contact between engineers.

3.6 MANAGEMENT

PERSONNEL REQUIREMENTS

PERFECT TEAMS

Litton Amecom understands that product quality and reliability are the ultimate measure of a company's development and productivity capabilities. To insure the integrity of all delivered products, they have implemented a number of programs to maintain a complete range of physical and human resources. One such program that has been successfully implemented by the Human Resources department is the Perfect Team concept.

The Perfect Team concept encourages employee participation in decisions effecting their workplace. Each team is comprised of a small group of employees (six to ten) from the same work unit, trained in the concept, meet on a continuing basis for one hour per week, discuss problems directly related to their work, investigate causes of problems, analyze solutions, implement and evaluate adaption.

A teams project typically starts with the selection of a long term problem and is completed with a presentation to management, with the Litton Amecom Division President in attendance.

The Perfect Team concept emphasizes employee involvement. The program recognizes that teamwork, if properly applied, can improve the competitive business climate of a company, through improved productivity, quality and performance, thus improving the value and

potential of each employee. The Perfect Team process at Litton Amecom has greatly improved morale, promoted teamwork, improved employee/management communications, reduced conflicts, and has taught employees to solve problems.

Because of the successes of the first two teams and the successes of teams at other Litton divisions, the Litton Amecom FY-90 Plan will include the continuation of the two existing teams and the addition of four new teams one in Operations, one in Product Assurance, and two in Engineering.

SECTION 4
PROBLEM AREAS

4.1 LOGISTICS

SPARES

MILITARY STANDARD REQUISITIONING AND ISSUE PROCEDURES SYSTEM

Litton Amecom serves as the depot repair facility on several military programs and has experienced problems using the Mili ary Standard Requisitioning and Issue Procedures (MIL-STRIP) system to obtain parts needed for equipment repairs. The MIL-STRIP procedure is extremely time consuming and the system is often NOT responsive. When a non-repairable item fails during the overhaul repair cycle, the repair part must be requisitioned using MIL-STRIP procedures. If the part is in government inventory, the requisition is normally filled in one to two months. If the part is not in inventory the government must procure and deliver it which takes an average of six months to one year, or the government can request a contractor to furnish the part which takes an average of two to six months. Authority and dollar allocation for parts that must be bought or made must come from DCAS Baltimore (ACO) which adds an average of six months to a year to the process. These delays are costly to both the government and contractor and degrade operational readiness. There is no known way of expediting the MIL-STRIP system. Litton Amecom recommends that procedures be developed which allow the contractor to go outside the MIL-STRIP system and procure parts less than a specified dollar value (i.e., $100). This would significantly improve the cost and readiness degradation due to repair delays caused by the MIL-STRIP system.

APPENDIX A

TABLE OF ACRONYMS

Acronym	Definition
AAMS	Automated Antenna Measurement System
AI	Artifical Intelligence
AMRF	Automated Manufacturing Research Facility
BMP	Best Manufacturing Practices
CAB	Corrective Action Board
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
CTE	Coefficient of Thermal Expansion
EDM	Engineering Development Model
EMPF	Electronics Manufacturing Productivity Facility
ESD	Electrostatic Discharge
ESM	Electronic Support Measures
MIC	Microwave Integrated Circuit
MIL-STD	Military Standard
MIL-STRIP	Military Standard Requisitioning and Issue Procedures
MOLE	Multi-channel Occurrent Logger Evaluation
MTI	Metalworking Technology Incorporated
PAD	Product Assurance Directive
PCB	Printed Circuit Board
PWB	Printed Wiring Board
QE	Quality Engineering
RADS	Reliability Assurance Data System
SRA	Shop Replaceable Assembly
UV	Ultra-Violet
WRA	Weapons Replaceable Assembly

APPENDIX B

BMP REVIEW TEAM

Team Member	Agency	Role
Alan Criswell (215) 897-6684	**Naval Industrial Resources Support Activity** Philadelphia, PA	**Team Chairman**
Ed Turrissini (317) 353-7950	**Naval Avionics Center** Indianapolis, IN Design/Test	**Team Leader** Design/Test
Bob Bixler (619) 553-1961	**Naval Ocean Systems Center** San Diego, CA	
Mark Dean (812) 854-3849	**Naval Weapons Support Center** Crane, IN	
Steve Rapp (812) 854-1694	**Naval Weapons Support Center** Crane, IN	**Team Leader** Production/Facilities
Larry Robertson (812) 854-3085	**Naval Weapons Support Center** Crane, IN	
Mary Kay Zeunik (317) 353-3714	**Naval Avionics Center** Indianapolis, IN	
Jerry Sergeant (309) 782-7800	**US Army Industrial** Engineering Activity Rock Island, IL	
Rick Purcell (202) 692-3383	**Office of the Assistant** Secretary of the Navy (S&L) (RM&QA-PI) Washington, D.C.	**Team Leader** Management/Logistics
Larry Halbig (317) 353-7075	**Naval Avionics Center** Indianapolis, IN	

APPENDIX C

PREVIOUSLY COMPLETED SURVEYS

BMP surveys have been conducted at the companies listed below. Copies of survey reports for any of these companies may be obtained by contacting:

Best Manufacturing Practices Program
Office of the Assistant Secretary of the Navy
(Shipbuilding and Logistics)
Attn: Mr. Ernie Renner, RM&QA
Washington, DC 20360-5000
Telephone: (202) 692-0121

COMPANIES SURVEYED

Litton
Guidance & Control Systems Division
Woodland Hills, CA
October 1985

Honeywell, Inc.
Underseas Systems Division
Hopkins, MN
January 1986

Texas Instruments
Defense Systems & Electronics Group
Lewisville, TX
May 1986

General Dynamics
Pomona Division
Pomona, CA
August 1986

Harris Corporation
Government Support Systems Division
Syosset, NY
September 1986

IBM Corporation
Federal Systems Division
Owego, NY
October 1986

Control Data Corporation
Government Systems Group
Minneapolis, MN
December 1986

Hughes Aircraft Company
Radar Systems Group
Los Angeles, CA
January 1987

ITT
Avionics Division
Clifton, NJ
September 1987

Rockwell International Corporation
Collins Defense Communications
Cedar Rapids, IA
October 1987

UNISYS
Computer Systems Division
St. Paul, MN
November 1987

Motorola
Government Electronics Group
Scottsdale, AZ
March 1988

General Dynamics
Forth Worth Division
Fort Worth, TX
May 1988

Texas Instruments
Defense Systems & Electronics Group
Dallas, TX
June 1988

Hughes Aircraft Company
Missile Systems Group
Tucson, AZ
August 1988

Bell Helicopter
Textron, Inc.
Fort Worth, TX
October 1988

Litton
Data Systems Division
Van Nuys, CA
October 1988

GTE
C^3 Systems Sector
Needham Heights, MA
November 1988

McDonnell Aircraft Comany
St. Louis, MI
January 1989

Northrop Corporation
Aircraft Division
Hawthorne, CA
March 1989

Litton
Applied Technology Division
San Jose, CA
April 1989

Information gathered from all BMP surveys is included in the Best Manufacturing Practices Management Information System (BMP-MIS). Additionally, a calendar of events and other relevant information are included in this system. All inquires regarding the BMP-MIS may be directed to:

Director, Naval Industrial Resources Support Activity
Attn: BMP-MIS System Administrator
Bldg. 75-2, Room 209, Naval Base
Philadelphia, PA 19112-5078
Telephone: (215) 897-6684